Power Factor Performance on 0.35 Mm and 0.50 Mm Thicknesses of Steel Sheets for 0.5 Hp Induction Motor Using FEM Software

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Abstract

Decrease the thicknesses of steel sheets will increase the power factor of the 0.5 Hp induction motor. This paper presents the effect of thicknesses in power factor for non-oriented electrical steel sheets. The study was carried out by using Finite Element Method (FEM) software for both thicknesses. Based on the analysis, it shows that the thickness of 0.35 mm has increment of 4% for the power factor compared to 0.50 mm.

Keywords

FEM Software; Power Factor; Induction Motor

Introduction

Induction machines represent a class of rotating apparatus that includes induction motors, induction generators, induction frequency converters, induction phase converters and electromagnetic slip couplings. The induction motor was invented by Nikola Tesla (1856 – 1943) in 1888. Induction motors can be used effectively in all motor application, except where very high torque or very fine adjustable speed control is required [1].

A rotating magnetic field, produced by a stationary winding (called the stator), induces an alternating emf and current in the rotor. They are more rugged, require less maintenance, and are less expensive than direct-current motors of equal power and speed ratings it requires electrical connections to the rotating member; the transfer of energy from the stationary member to the rotating member is by means of electromagnetic induction. The resultant interaction of the induced rotor current with the rotating field of the stationary winding produces motor torque [2].

A low power factor is the result of inductive loads such as transformers and electric motors. Unlike resistive loads creating heat by consuming kilowatts, inductive loads require a current flow to create magnetic fields to produce the desired work. Power factor is an important measurement in electrical AC systems because an overall power factor less than 1 indicates that the electricity supplier need to provide more generating capacity than actually required and the current waveform distortion that contributes to reduced power factor is caused by voltage waveform distortion and overheating in the neutral cables of three-phase systems. The power factor of an AC electric power system is defined as the ratio of the active (true or real) power to the apparent power where Active (Real or True) Power is measured in watts (W) and is the power drawn by the electrical resistance of a system doing useful work, Apparent Power is measured in volt-amperes (VA) and is the voltage on an AC system multiplied by all the current that flows in it. It is the vector sum of the active and the reactive power and Reactive Power is measured in volt-amperes reactive (VAR) [3].

In recent years, the finite element method has become a very popular and practical tool for computing magnetic fields in electrical apparatus. Their design parameters are evaluated from the formulae based on the approximations to actual flux distribution in the machine cross section. In the past, approximate methods have sufficed. However, at the present time, there is a greater need to build more efficient machines and to utilize material more economically [4].

The thinner the steel the more effectively eddy currents are restrained and the lower the core losses. Thinner steel costs more to produce and requires more press-blows to make lamination stacks of a given size. However a lamination pile of a given height contains less metal if made of 0.35mm steel rather than of 0.50mm steel due to the effect of the extra surfaces on the stacking factor [5].

FEM Modelling

Figure 1 shows the design specification of the induction motor in millimeters. The overall motor stator and rotor design is 55mm in radius. The overall rotor radius is 33.75mm. Based on Figure 1, it shows the rotor slot type called the round bar rotor slot type and the diameter of each slot that will be altered. The usage of this slot pattern is because it has a discrete 'starting bar' isolated from the main body of the conductor bar by a 'leakage slot', are applicable to motors with high conductivity material in the rotor cage. Besides that, this design of rotor bar has a higher locked rotor torque and a high slip [6].

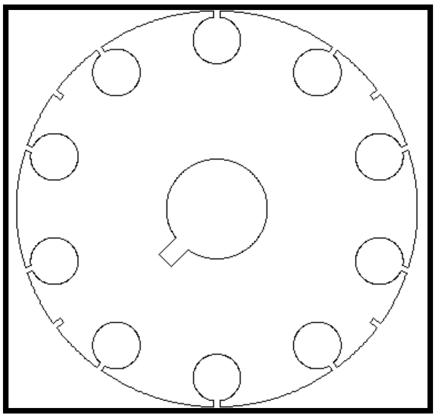

FIG 1 AUTOCAD DESIGN OF ROTOR BAR FOR BOTH THICKNESSES

Figure 2 shows the FEM model simulated by using the AC Analysis solver. The result is then arranged to Table 1 which the nameplate data 0.5Hp induction motor for both thicknesses. Input such as motor horse power, input voltage and frequency is inserted into the FEM software and the remaining result in Table 1 is the output from the FEM software.

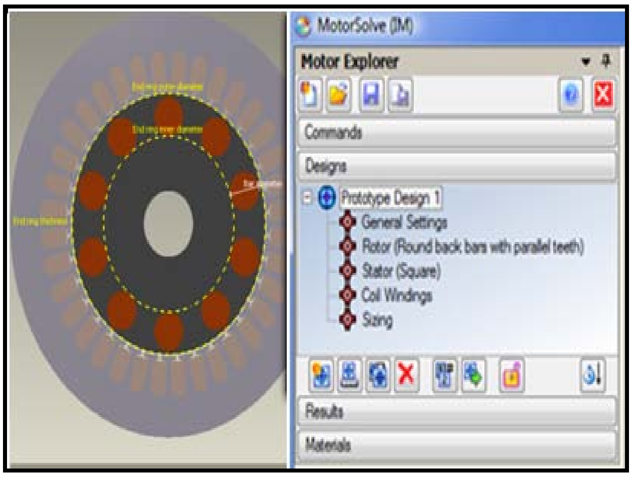

FIG 2 THE DESIGNED FEM MODEL OF 0.5HP INDUCTION MOTOR FOR BOTH THICKNESSES

TABLE 1 0.5HP INDUCTION MOTOR NAMEPLATE FOR BOTH THICKNESSES

	0.35mm	0.5mm
Phase	3	3
Frequency	50	50
Voltage	415	415
RPM	1425	1425
Current	0.9025	1.1495
Horsepower	0.487	0.598
Power Factor	0.75	0.72
Efficiency	82.5	80.7

The motor are design to have 36 stators and 10 rotor slots using copper; the FEM uses steady-state AC analysis solver for both thicknesses of rotor slot design. Based on simulation, results from both thicknesses rotor slots are analysed and its properties differences are stated. In this simulation, copper conductivity is 5.77×10^{7} sm^{-1}.

The BH curve used for both thicknesses of non oriented electrical steel modeling has shown as Figure 3. The BH curve assigned to the FEM Software design is below 1.8T.

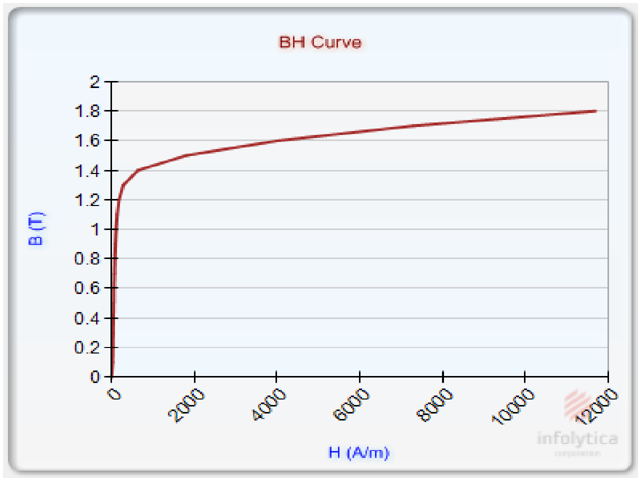

FIG 3 BH CURVE FOR BOTH THICKNESSES OF MATERIAL

Power factor

Figure 4 shows the power factor vs. Speed for both thicknesses of non-oriented electrical steel for rotor frame which are 0.35 mm and 0.50 mm. That figure shows that power factor is highest near rated load. Based on the graph, the value of power factor for 0.35 mm thickness is higher than 0.50 mm, which is 0.75 and 0.72 respectively. Based on analysis, it shows that the 0.35 mm has increment of 4% for the power factor

compared to the 0.50 mm thickness of steel sheet. This is because; high power factor in induction motor can reduce harmonic and motor energy losses. It also shows that losses and power factor at an induction motor can affect the efficiency of the induction motor.

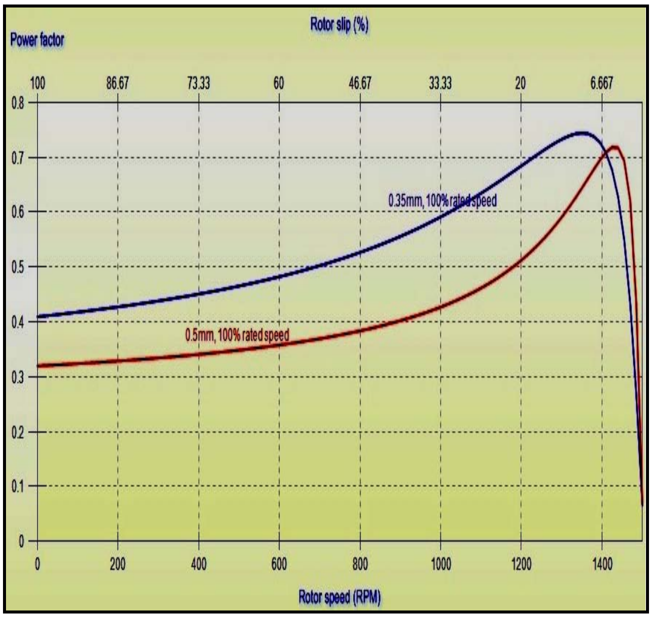

FIG 4 POWER FACTOR VS. SPEED FOR BOTH THICKNESSES OF MATERIAL

Conclusion

Based on FEM software simulation, it shows that the 0.35 mm has an increment of 4% for the power factor compared to that of 0.50 mm thicknesses steel sheet. That means the value of power factor for 0.35 mm is higher than the 0.50 mm thickness. High power factor in induction motor can reduce harmonic and motor energy losses. Thus, rotor frame using 0.35 mm thickness of non oriented electrical steel 10 mm slot rotor with copper is the best choice for implementation in the induction motor.

ACKNOWLEDGMENT

The authors wish to express appreciation to Lecturer, staff and friends of Center of Excellence for Renewable Energy (CERE) & School of Electrical System Engineering, UniMAP for their willing with this work and technical support and also to Infolytica for the Motorsolve (IM) software.

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Biographies

Yanawati Binti Yahya was born in Sibu Sarawak, Malaysia on July 8, 1979. She is a postgraduate student in Electrical System at Engineering University of Malaysia Perlis (UniMap). She received her Diploma in Industrial Electronics Technology at University Technology Malaysia (UTM) in 2001 and B.Eng. (Hons) in Industrial Electronic Engineering at UniMap in 2009. She then received her MSc. from UniMAP in 2012.

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Pungut Ibrahim was born in Labuan Federal Territory in 1964. He received his B. Eng (Hons) in Electrical Engineering from UTM, Kuala Lumpur in 1987. He works as Power Plant Shift Superintendent for 5 years, Maintenance Engineer for 132kV Substations and Transmission Line installations for 12 years before joined Sabah Electricity Sdn Bhd for a year and Class A electrical contractor for another year. He joined UniMap in 2009 as Teaching Engineer in School of Electrical Engineering.